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FUMIGANTS, THEIR PROPERTIES AND APPLICATION

By Joe E. Brooks

A. Properties and Application

Fumigants are used to kill rodents and their ectoparasites living in inaccessible areas in buildings, ships or in burrows in the soil. Fumigants are quite dangerous, both to the persons using them and to other humans or animals in the immediate area. Experience and skill are required therefore in their application. Fumigants most commonly used against rodents are calcium cyanide (to produce hydrogen cyanide), methyl bromide, chloropicrin and aluminium phosphide (to produce phosphine). More rarely used are carbon dioxide, carbon monoxide and sulfur dioxide.

Fumigants having a molecular weight less than 29 tend to rise to the top of burrow systems when used in the soil. Factors that can be important in burrow fumigation are the moisture content of the soil and its particle size. Hydrogen cyanide, methyl bromide and hydrogen phosphide are extremely toxic gases and great caution must be taken to avoid inhaling them when fumigating burrows, confined spaces or commodities under gasproof tarpaulins. Some characteristics of commonly used fumigants are given in Table 1.

Table 1. Some Characteristics of Rodent Fumigants

Fumigant	Chemical structure	Molecular weight	Physiological action*	LD_{50}(rat) mg/litre	Flammable
Hydrogen cyanide	HCN	27	C.A.	0.4	Yes
Carbon monoxide	CO	28	C.A.	(0.35%conc)	No
Hydrogen phosphide	PH_3	34	I.	0.8	Yes
Carbon dioxide	CO_2	44	S.A.	(20-30% conc)	No
Sulfur dioxide	SO_2	64	I.	1.6	No
Methyl bromide	CH_3Br	95	I.	3.6	No
Chloropicrin	CCl_3NO_2	164	I.	2.0	No

* C.A. = Chemical asphyxiant; S.A. = Simple asphyxiant; and I. = Irritant.

1. Calcium cyanide

Calcium cyanide $Ca(CN)_2$, is most frequently used in outdoor operations (it should not be used closer than 3 m to buildings); it is greyish-white and available in a granular or powdered form. The granules or powder are blown or spooned into a burrow and hydrogen cyanide (HCN) is liberated when they come into contact with moist air or soil. Hydrogen cyanide is lighter than air and the gas accumulates in all the upper parts of the burrow network; thus all holes must be sealed quickly. Calcium cyanide is usually blown into burrows using a special commercially available pump. The hose is inserted into the burrow opening and soil packed around it. Five or six strokes are then made with the pump handle, the valve switched to "air" and about 10 more strokes applied to blow the powder further into the burrow system. Entrances into the treated burrow are then immediately closed with soil. A second person should stand by with a stick or other weapon, ready to kill any rats that bolt from the burrow system. Holes reopened in a day or so will indicate whether some rodents have survived, and the burrow system then should be retreated.

Gassing with cyanide should always be done by more than one operator, for HCN is quick-acting and a person working alone could become exposed and die without help. Workers using calcium cyanide should carry ampoules of amyl-nitrate as a first-aid measure in case of accidental poisoning. A broken ampoule is held under the nose of the affected person for 30 seconds out of every two minutes and a physician should be called immediately. Death may result from a few minutes exposure to 300 ppm HCN.

2. Methyl bromide

Methyl bromide (CH_3Br), is an odourless, highly toxic gas used in general pest fumigation, mainly indoors for insect control and, occasionally, against rodents. Methyl bromide cylinders with a valve and hose attached are used to fumigate rodent burrows in the same way as hydrogen cyanide. The hose is inserted into the burrow, soil is packed around it, and the valve opened for several seconds, releasing 15-30 ml of liquid methyl bromide into the burrow. The burrow is then closed and examined a day or two later. Methyl bromide should not be used near roots of trees or shrubs, as it is toxic to plants. Hazards associated with using methyl bromide in rodent control operations demand that the work is carried out with care by experienced operators and precautions taken to prevent the liquid material from getting in the eyes, mouth or on the skin. The wearing of gloves is not advised since any liquid penetrating them can become trapped and cause serious burns to the skin. Methyl bromide should not be used at low temperatures (below 2-4^{o}C) as the liquid will not vapourize and the valve on the cylinder may freeze up. Fumigation of ships and warehouses has been conducted but some goods, e.g. flour, may become tainted and should never be treated.

3. Chloropicrin

Chloropicrin (CCl_3NO_2), sometimes known as tear gas, has been occasionally used to drive house mice out of grain storage areas. Mice die even when subjected to a concentration of less than 32 ppm of chloropicrin. Mixed with heavy motor oil, chloropicrin has been suggested as a burrow fumigant for rats and sometimes a small quantity is mixed with methyl bromide to provide an olfactory warning to the person using that gas. Overexposure to chloropicrin produces severe sensory irritation in the lungs apart from severe lachrymatory effect and this chemical is also a strong skin irritant.

4. Hydrogen phosphide

Hydrogen phosphide (PH_3), also known as phosphine, has been used as a fumigant against insects infesting stored products for many years. The gas is liberated from a highly compressed tablet compound of ammonium carbonate and aluminium phosphide. When the tablet is exposed to moisture, it decomposes into hydrogen phosphide, aluminium hydroxide, ammonia and carbon dioxide. A tablet weighing 3 g liberates 1 g of hydrogen phosphide. Hydrogen phosphide is a colourless, poisonous, spontaneously flammable gas, slightly heavier than air, with a sharp garlic-like odour. The odour may not be a sufficient warning, however, to workers accustomed to the use of the gas. The prepared tablet is relatively safe to handle; it is not selfcombustible, but should not be exposed to an open flame. Workers handling the tablets should wear gloves.

Hydrogen phosphide is sometimes used to fumigate burrows of *Rattus norvegicus, Bandicota bengalensis* and *Nesokia indica* in parts of Asia and elsewhere. Normally one or two tablets are placed into each burrow entrance and the openings are then closed with soil. The speed of liberation of the gas in burrow systems is dependent upon both soil moisture and temperature levels but it normally takes several hours to fumigate a burrow.

5. Carbon dioxide

Carbon dioxide (CO_2), has been occasionally used to fumigate cold storage warehouses and corn-ricks against house mice. It was found that CO_2 concentrations of 23% or greater killed wild house mice in less than two hours and that the gas was most easily and economically applied using solid CO_2 (dry ice). Dry ice has been proposed for fumigating refrigerated warehouses where low temperatures must be maintained. The ice is crushed and distributed throughout the room; an electric fan is then used to disperse the gas. Approximately 2 kg dry ice/m^3 of space is needed to give a 15% concentration of gas over 24 hours.

6. Carbon monoxide

Carbon monoxide (CO), from petrol engine exhaust fumes, can be used to kill rats in outdoor burrows. A flexible hose is attached to the exhaust pipe and the other end is inserted inside the burrow. All of the burrow openings are then sealed and the engine run for about five minutes. Precautions must be taken to ensure good ventilation of the vehicle since carbon monoxide might be forced back along the exhaust system and leak into it.

A carbon monoxide cartridge has been developed containing sodium nitrate and charcoal that has proved useful in control of burrowing rodents. It contains 65 parts sodium nitrate and 35 parts charcoal. Another version containing 55 parts potassium nitrate and 45 parts sawdust has also been used.

7. Sulfur dioxide

Sulfur dioxide (SO_2), is a colourless, non-flammable gas with a strong suffocating odour. It is intensely irritating to the eyes and to the respiratory tract. Sulfur dioxide was formerly used to fumigate rat-infested ships but now it is mainly used in the preservation of fruits and vegetables. Sulfur, mixed with potassium nitrate (saltpetre) and a small amount of tallow constitutes the so-called "smoke ferrets"; the smoke produced on burning has been used to make rats run from their burrows when they can be killed by force. This method can also be used for the rapid collection of live rats, needed for laboratory and other experimental purposes, such as the examination of ectoparasites. The use of SO_2 as a general burrow fumigant is not recommended, however.